1.2. BARROW OBSERVATORY

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1.2.1. OPERATIONS

Begun in January 1973, operations at Barrow Observatory (BRW), Barrow, Alaska, have grown from a small program to one that now touches upon, or supports components of, almost every major climate change study in the U.S. Arctic. In addition to a full suite of CMDL measurements, programs include research activities from several U.S. government agencies and a broad selection of universities in the United States and other countries. As the Arctic becomes recognized as the location where global climate warming will probably be observed first and where the effects of the warming will be relatively easy to detect, BRW measurements and facilities are becoming ever more in demand.

In 2001 a new garage with greater square footage than the main laboratory was constructed to house observatory vehicles and up to 100 large compressed gas cylinders. There is also room for a small workshop and storage. The ability to park vehicles in a warm garage will save on vehicle maintenance and will allow for a safe and dry environment to unload, pack, and unpack shipments. Compressed gas cylinders were previously stored at the Air Force Long Range Radar Site, formerly the Distant Early Warning (DEW) Line site, in an unheated storage building one-half mile from the Barrow station or at the station on the tundra in summer mud or under snow in the winter. All the small, old buildings on site were removed as part of the garage-building program; this has resulted in a much-improved overall appearance.

Construction on the BRW access road was essentially completed at the end of summer 2000, and it was graded in 2001. By summer 2002 the road will be settled to the point that the final gravel coating can be applied. The road was passable to wheeled vehicles most of winter 2000-2001 for the first time ever, with only minor interruptions from drifting snow.

From 1994 to 2000 there were no personnel changes at BRW. In 2000 the station chief completed 16 years at BRW and the electronics technician 6 years. In July 2000 the technician transferred to the CMDL American Samoa Observatory (SMO) and was replaced with a technician who had previously worked at BRW. This technician left in December 2000 and will be replaced by a technician who formerly wintered at the CMDL South Pole Observatory (SPO).

The station staff continues to be involved with the Barrow Arctic Science Consortium (BASC), and the station chief is a member of the Barrow Environmental Observatory Management Committee. The station chief will travel to Nome, Alaska, in January 2002 to help train five native students and two teachers from villages along the Bering Sea coast of Russia in techniques for the collection of snow samples for later analysis of the mercury content. The chief will similarly train a number of native students and teachers from the North Slope of Alaska. The project is a 5-yr effort funded by the U.S. State Department and the U.S. Environmental Protection Agency (EPA) through BASC to determine the extent and severity of mercury pollution in Bering Sea coastal areas of Alaska and Russia. Mercury found in the milk of native subsistence hunter mothers is believed to have its origins in power plant plumes flowing into the Arctic from lower latitudes.

In the middle of 2001 Internet service to BRW, supplied by the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program, was reduced from T-1 to 256K service when the cost of a T-1 connection increased 560%. As a consequence, access to many web pages needed for efficient station operation is no longer possible. A return to T-1 connectivity is being pursued.

In 2000-2001, 232 visitors to BRW signed the guest book, including the acting administrator of NOAA and documentary television crews from England and Japan. The community of Barrow hosted the Alaska Presswomen convention in 2001, which brought reporters from around the United States to Barrow. A group of journalists from the meeting visited BRW to gather information for their local newspapers and magazines. For one of many resulting articles, BRW was featured on the cover of *Biology Digest*.

The Y2K problem turned out to be a non-event for BRW. All data computers passed through the change of the year with no problems. One old office computer experienced some difficulties, signaling that it was in need of replacement.

1.2.2. PROGRAMS

Table 1.2 lists programs for 2000-2001 at BRW as well as cooperative programs that operated in 2000-2001 and that are approved for 2002. Highlights of the programs are as follows:

Gases

Carbon dioxide. The CO_2 system continues to have problems associated with aging components. The Siemens Ultramat 5-E analyzer is showing signs of a temperature-dependent signal. The solution has been to leave the door to the rack open for better airflow around the instrument.

Flask samples. Flask samples were collected as available and as scheduled with no major problems. Isotopic composition measurements of CO_2 continue, and data from this program can be found elsewhere in this report.

Methane. The HP-6890 gas chromatograph (GC) continues to run with very few problems. Data show a clearly defined annual frequency, with higher values occurring in the winter months and lower values in the summer.

Total column ozone. Dobson spectrophotometer no. 91 ran well the entire period with no major problems. Regular calibrations were performed to maintain data quality at a high standard. A noisy bearing will be repaired when the BRW instrument is sent to Boulder in winter 2002 for recalibration. Dobson measurements are not possible during the winter months because of the lack of sunlight, so no measurements will be missed during the recalibration of the instrument. Column ozone values as high as 400 Dobson units (DU) and values as low as 290 DU were recorded over the past 2 years.

Carbon monoxide. A Trace Analytical GC has been the station instrument since 1991 and continues to run with

TABLE 1.2. Summary of Measurement Programs at BRW in 2000-2001

Program/Measurement	Instrument	Sampling Frequency
Gases		
CO_2	Siemens Ultramat 5-E analyzer	Continuous
	3-L glass flasks	1 pair wk^{-1}
	0.5-L glass flasks, through analyzer	1 pair wk^{-1}
CO_2, CH_4, CO, and $^{13}C/^{12}C$ and $^{18}O/^{16}O$ of CO_2	0.5-L glass flasks, P^3 pump unit	1 pair wk^{-1}
CH_4	Carle automated GC	1 sample (12 $min)^{-1}$
Surface O_3	Dasibi ozone meter	Continuous
Total O_3	Dobson spectrophotometer no. 91	3 day^{-1}
CO	Trace Analytical GC	1 sample (6 $min)^{-1}$
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4, SF_6, HCFC-22, HCFC-21, HCFC-124, HCFC-141b, HCFC-142b, HCFC-152a, CH_3Br, CH_3I, CH_3Cl, CH_2Cl_2, $CHCl_3$, CH_2Br_2, $CHBr_3$, C_2Cl_4, H-1301, H-1211, HFC-134a, C_6H_6, COS	850-mL, 2.5-L, or 3-L stainless-steel flasks	1 pair wk^{-1}
CFC-11, CFC-12, CFC-113, N_2O, CH_3CCl_3, CCl_4, CH_3Br, CH_3Cl, H-1211, SF_6, HCFC-22, HCFC-142b, $CHCl_3$, COS	Automated CATS GC	1 sample h^{-1}
Aerosols		
Condensation nuclei	Pollak CNC	1 day^{-1}
	TSI CNC	Continuous
Optical properties	Three-wavelength nephelometer	Continuous
	Radiance Research PSAP	Continuous
Black carbon	Aethalometer	Continuous
Solar Radiation		
Global irradiance	Eppley pyranometers with Q and RG8 filters	Continuous
Direct irradiance	Tracking pyrheliometer	Continuous
	Eppley pyrheliometer with Q, OG1, RG2, and RG8 filters	Discrete
Albedo	Eppley pyranometer	Continuous
Ultraviolet B irradiance	NILU radiometer	Continuous
	Yankee UVB radiometer	Continuous
Ultraviolet spectral irradiance	Biospherical five-wavelength photometer	Continuous
Aerosol optical depth	Carter-Scott four-wavelength sunphotometer	Continuous
Terrestrial (IR) Radiation		
Upwelling and downwelling	Eppley pyrgeometers	Continuous
Meteorology		
Air temperature	Thermistor, two levels	Continuous
	Max.-min. thermometers	1 day^{-1}
Dewpoint temperature	Dewpoint hygrometer	Continuous
Pressure	Capacitance transducer	Continuous
	Mercurial barometer	Discrete
Wind (speed and direction)	R.M. Young aerovane	Continuous
Precipitation	Rain gauge, tipping bucket	Continuous
Cooperative Programs 2000-2001		
Total surface particulates (DOE)	High-volume sampler (1 filter wk^{-1})	Continuous
Precipitation gauge (USDA)	Nipher shield, Alter shield, two buckets	1 mo^{-1}
Magnetic fields (USGS)	Three-component fluxgate magnetometer and total field proton magnetometer	Continuous
	Declination/inclination magnetometer sample	6 sets mo^{-1}
CO_2, ^{13}C, N_2O (SIO)	5-L evacuated glass flasks (3 flasks set^{-1})	1 set wk^{-1}
CH_4 (Univ. of Calif., Irvine)	Stainless-steel flasks	1 set (3 $mo)^{-1}$
O_2 in air (Princeton)	3-L glass flasks	1 pair wk^{-1}
CO_2 flux (San Diego State Univ.)	CO_2 and H_2O infrared gas analyzer and sonic anemometer	Continuous, check site 1 wk^{-1}

TABLE 1.2. Summary of Measurement Programs at BRW in 2000-2001—continued

Program/Measurement	Instrument	Sampling Frequency
Cooperative Programs 2000-2001—continued		
Magnetic fields (NAVSWC)	^{3}He sensors	Continuous
Magnetic micropulsations (Univ. of Tokyo)	Magnetometer and cassette recorder	1 (3 wk)$^{-1}$
UV (NSF)	UV spectrometer	1 scan (0.5 h)$^{-1}$
Thaw depth in permafrost (SUNY)	Temperature probe	Continuous
Total VOC and heavy metals (Hokkaido Univ.)	Filter samples	1 h^{-1}
Atmospheric mercury (EPA)	Mercury vapor monitors	Continuous, spring
Atmospheric mercury (NOAA/ARL)	Mercury vapor monitors	Continuous
Arctic coastal ice characteristics (Univ. of Washington, Seattle) (began 2001)	Optical sensors	Continuous
POES satellite transmission downlink (NESDIS) (began 2001)	3-m dish and receiver	Continuous
Eider duck migration patterns (Univ. of Alaska, Fairbanks) (began 2001)	Radar and optical observations	Seasonal
Soil organic matter (Univ. of Alaska, Fairbanks) (began 2001)	Vegetation samples	Discrete
Organochlorine contaminants (Oregon State Univ.) (began 2001)	Air samples	Discrete weekly
Snow radiation (JMA/MRI, Japan) (began 2001)	Albedo and reflections from snow	Continuous
Mercury in snow (Univ. of Michigan) (began 2001)	Snow samples	Winter season
Cooperative Programs Approved for 2002		
Persistent organic pollutants (Battelle-Northwest Labs.)	High-volume pump	Continuous
SuomiNet GPS meteorology station (Univ. of Alaska, Fairbanks)	GPS water vapor measuring station	Continuous
NOAA Climate Reference Network Station	Global climate reference station	Continuous
Dimethyl sulfide (Univ. of Alaska, Fairbanks)	Gas chromatograph	Continuous
Removal mechanisms of Arctic haze (Wayne State Univ.)	Aerosol samples	Continuous, weekly filter change
Optical properties of Arctic ecosystems (California State Univ.)	Multispectral optical sensors	Continuous

JMA/MRI, Japan Meteorological Agency/Meteorological Research Institute.

minimal maintenance. The major work to the system this past year was replacement of the Hg scrubber and the UV lamp.

Halocarbons and other atmospheric trace species. The Chromatograph for Atmospheric Trace Species (CATS) ran well with only minor problems. Fourteen compounds are measured in situ with the CATS system. The most notable problem over the past 2 years was an inoperative water trap that produced poor data on one of the four channels for a short period of time. After the trap was replaced, the instrument has run properly. A flash heater for the cryo-cooler was replaced when the old one burned out.

Halocarbon flask samples were collected on a routine schedule and provide a comparison for in situ instrument performance. They also enable analysis of chemical species that are not measured in the field.

Aerosols

Arctic haze, air pollution from Eurasia, continues to dominate the springtime aerosol measurements at BRW. The haze concentrations build up over winter followed by declines in late spring/early summer when persistent cloudiness returns to the North Slope. The aerosol equipment ran well for the entire 2000-2001 period with only minor problems. Personnel from Boulder performed annual maintenance and system calibrations. All data from the aerosol system are monitored directly from Boulder in real time via the Internet except the aethalometer black carbon measurements that are first collected on floppy disks before being transferred to the aerosol program computer.

Solar Radiation

Several new solar radiation instruments were installed over the 2000-2001 period to specifically measure ultraviolet B (UVB) radiation. One such instrument from Norway, the Norwegian Institute for Air Research (NILU) UVB irradiance radiometer, was found to be less than satisfactory for conditions in BRW. A Yankee UVB radiometer installed about the same time is operating up to design specifications. A third UVB spectral irradiance photometer, from Biospherical Inc., also appears to operate well. A new sunphotometer, the SP0-1 manufactured by Carter-Scott, was installed in summer 2000 for testing. It was sent to Boulder for calibration during the winter and was subsequently replaced with the SP0-2 in spring 2001. The SP0-2 had a few problems with water leaking into the data/control cable connector, but otherwise it worked well.

In October 2001 a new albedo rack was installed in the clean-air sector, moving the sensors from 1.2 m (4 ft) above ground level to 3.7 m (12 ft). This affords a broader field of view for the sensors.

The majority of data quality issues in the solar radiation program during 2000-2001 came from instrument grounding problems that produced noisy data. Complete replacement of grounding lines on a number of instruments fixed the problem.

Meteorology

The meteorology system had some problems with the Metrabyte modules during 2000-2001. One module lost its program and had to be reinitialized. There were some problems with the dewpoint sensor due to corrosion, and the sensor head was replaced. All other sensor probes were calibrated and adjusted as needed.

Cooperative Programs

The largest new program was a study funded by the NOAA Arctic Research Office and undertaken by the NOAA Air Resources Laboratory (ARL) and CMDL to continuously measure mercury concentrations in air and the flux of mercury into and out of snow. This program entailed installation and maintenance of instrumentation along with mounting of sensors on the roof of the main building. The program will continue to operate through 2002 and possibly much longer. For 2 months each in spring 2000 and 2001, the U.S. EPA operated complementary mercury in air and mercury flux studies at BRW.

The newest cooperative program at BRW comes from the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) and consists of a satellite downlink antenna (3-m diameter) to collect data from the Polar Operational Environmental Satellite (POES) series of polar-orbiting satellites. This is not a cooperative science program in the traditional sense, but the BRW station now has near-real-time access to polar views of cloud, ice, and coastal conditions that will aid in the interpretation of data and the planning of measurement timetables. If this program proves to be of high value to NOAA/NESDIS, a feasibility study will be conducted to determine if a 13-m dish could be installed at BRW to control the POES satellites. The installation of the NESDIS facilities will eventually necessitate T-1 or T-3 data transmission lines to the BRW site. This will benefit CMDL in that the added Internet transmission capabilities will be made available for BRW observatory use.

A number of relatively short cooperative programs operated at Barrow, such as a University of Alaska study of eider duck migration with a radar device mounted at the BRW facility; a soil organic and winter CO_2 flux study, also from the University of Alaska; Arctic vegetation studies by the University of Colorado; and mercury in snow sampling by a scientist from the University of Michigan.

An unprecedented number of cooperative programs will be coming to BRW in 2002 and many of them have required the construction of new infrastructure in 2001. For instance, a NOAA/ARO-funded project to measure persistent organic pollutants (POPs) in the atmosphere, to be conducted by Battelle-Northwest Laboratories, Richland, Washington, necessitated construction of an extension to the filter platform and a small, enclosed filter-changing room. The platform extension required the insertion of four pilings 5.5 m (18 ft) into the permafrost. Another piling was installed to support a Global Positioning System (GPS) antenna for an University of Alaska water vapor monitoring program, also to begin in spring 2002. Three more pilings were inserted to support instrumentation for a Climate Reference Network (CRN) site to be installed by the NOAA National Climatic Data Center (NCDC), also in spring 2002. The long-term stability of BRW made the site an ideal place for CRN instruments. Instrumentation from the University of Alaska to measure dimethyl sulfide in a continuous mode will be installed in late spring 2002, and a program from Wayne State University to measure radiochemicals in Arctic haze will also begin in late spring 2002.